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(54) Method and apparatus for resistance measurements on a semiconductor element.

(57) A method for measuring the resistance or conductivity between two or more conductors which are placed against a semiconductor element, wherein in order to bring the contact resistance between the conductors and the element to and hold it at a predetermined value during measuring, the conductors are held at a constant distance and/or under constant pressure relative to the semiconductor element.

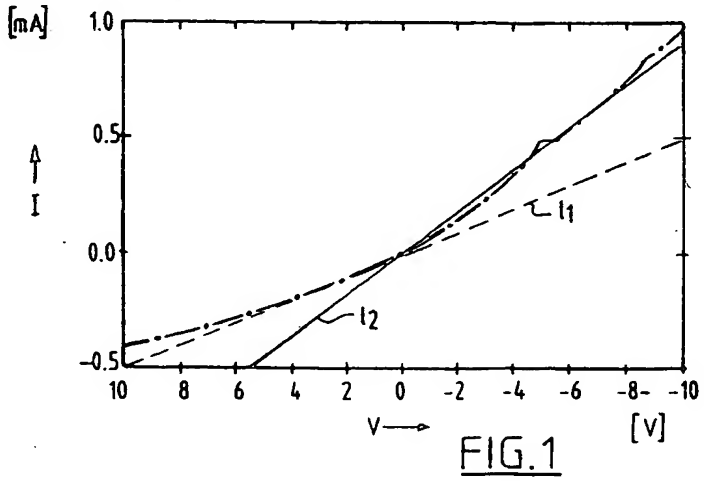

FIG.1

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A known technique for measurement on a semiconductor element is called Spreading Resistance Probe (SRP). A semiconductor element is herein cut obliquely and the resistance between in each case two probe points placed on the surface is measured. These probe points or conductors are placed at an interval of approximately 15 to 50 μm. The angle of inclination is in the region of several minutes to several degrees. The conductors are stepped over the obliquely cut portions with a step size in each case of 2.5 to 5 μm. In the SRP technique the resistance measurement can take place with both direct voltage and alternating voltage.

A problem here is the deviation in the contact resistance between conductor and semiconductor element. The point of the conductor is accurately polished, which can sometimes take days, until the contact resistance on a calibration sample reaches a predetermined value. Even after the time-consuming calibration of the points of the conductors the deviation in the contact resistance results in inaccuracies in the measurements.

The present invention has for its object to provide a new method wherein the accuracy of resistance measurements on a semiconductor element is considerably improved.

For this purpose the invention provides a method according to claim 1.

The preferred embodiments of the method (and the device) according to the present invention are designated in the dependent claims.

Further details, features and advantages of the present invention will become apparent in the light of the following description of a preferred embodiment according to the present invention with reference to the annexed drawing, in which:

Fig. 1 shows a graph of a current-voltage characteristic measured on a first semiconductor element and according to a first preferred method according to the present invention; and

Fig. 2 shows a graph of a current-voltage characteristic measured on a second semiconductor element and according to a second preferred method according to the present invention.

Fig. 1 and 2 are measured using an AFM arrangement (Atomic Force Microscopy). Herein a semiconductor element is movable three-dimensionally with piezo-crystals, a first of which adjusts the pressure or distance of a conducting needle relative to the semiconductor element, while two others enable a movement over the surface of the semiconductor element. A laser beam is directed onto the contact point of the conductor and the semiconductor element. The reflection of the laser beam is picked up in a photodiode, wherein the output of the photodiode is fed back to the first mentioned piezo-crystal.

In the measured graphs use is made of a tungsten wire of 20 μm diameter which is cut to a point. The curve of fig. 1 is measured on a semiconductor element with a relatively high resistivity, $\rho \approx 4.7$ Ω.cm. Applying a pressure force of constant value between the conductor and the semiconductor element results in an approximately linear current-voltage characteristic 1_1 at negative voltage and 1_2 at positive voltage.

Fig. 2 shows measurements on a substrate with a comparatively smaller resistivity $\rho \approx 0.0084$ Ω.cm. Different measurements are indicated with different curves in fig. 2 and show an approximately linear relation (1_3 and 1_4), wherein the angles of slope of the lines (1_3 and 1_4) are dependent on the applied pressure between conductor and semiconductor element.

By applying the pressure force between the semiconductor element and the conductor, this conductor penetrates through a thin oxide layer which in practice is almost always present on the semiconductor element. The pressure force can be held very constant because of feedback to the first mentioned piezo-crystal. Using the two above mentioned piezo-crystals the conductors are moved over the surface for measuring the resistance or conductivity along the sloping surface, wherewith the resistance at different depths in the semiconductor element becomes known.

Another technique which makes use in accurate manner of the control of a conductor over a for instance semiconducting element is so-called Scanning Tunneling Microscopy, wherein use is made of the tunnel flow between conductor and that element for holding the conductor at constant distance relative to the surface of that element. The oxide layer over the semiconductor element can form a problem here.

An important novel feature of the method according to the present invention relates to the possibility of measuring either with DC current and/or voltage, or AC voltage or current.

Good results have been obtained by measuring with AC voltage and using a DC bias voltage.

Claims

1. A method for measuring the resistance or conductivity between two or more conductors which are placed against a semiconductor element, wherein in order to bring the contact resistance between the conductors and the element to and hold it at a predetermined value during measuring, the conductors are held at a constant distance and/or under constant pressure relative to the semiconductor element.

2. A method as claimed in claim 1, wherein the measurement takes place according to the Spreading Resistance Probe technique (SRP).

3. A method as claimed in claim 1 or 2, wherein use is made of an AFM arrangement (Atomic Force Microscopy).

4. A method as claimed in claim 1, 2 or 3, wherein the conductor is manufactured from tungsten.

5. A method as claimed in claim 4, wherein use is made of a tungsten thread of 20 μm diameter on which a point has been cut as is usual in STM techniques (Scanning Tunneling Microscopy).

6. A method as claimed in any of the foregoing claims, wherein a force is applied between the element and the conductor such that the latter penetrates through the layer of natural oxide on the element.

7. A method as claimed in claim 1, wherein use is made of a Scanning Tunneling Microscope (STM).

8. A method according to anyone of the foregoing claims, using DC voltage (current) and/or AC voltage (current).

9. An apparatus for performing the method as claimed in any of the foregoing claims.

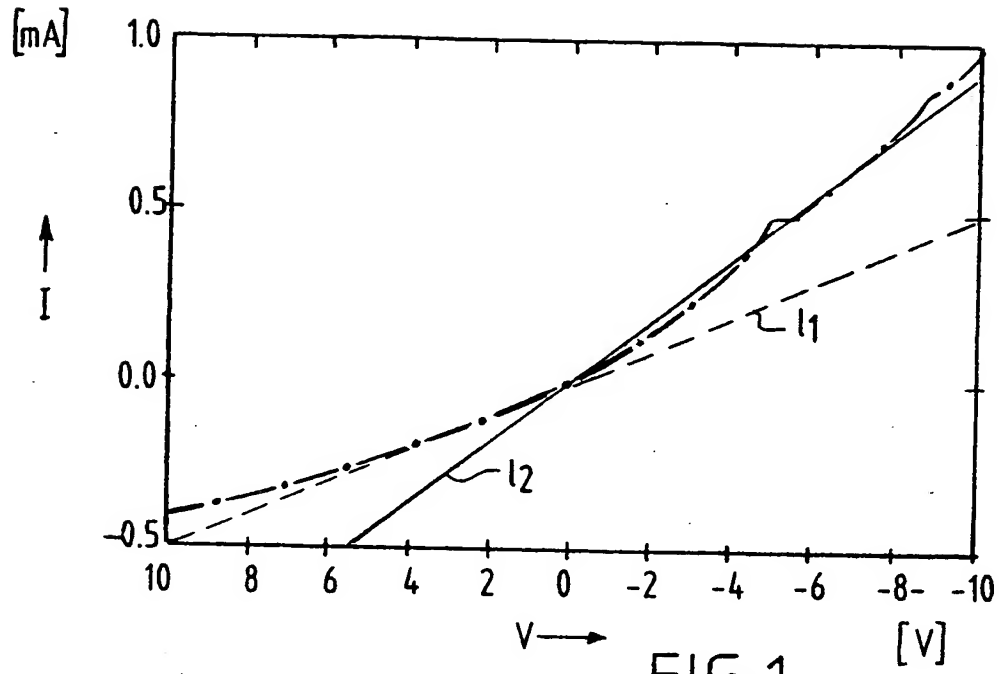
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FIG.1

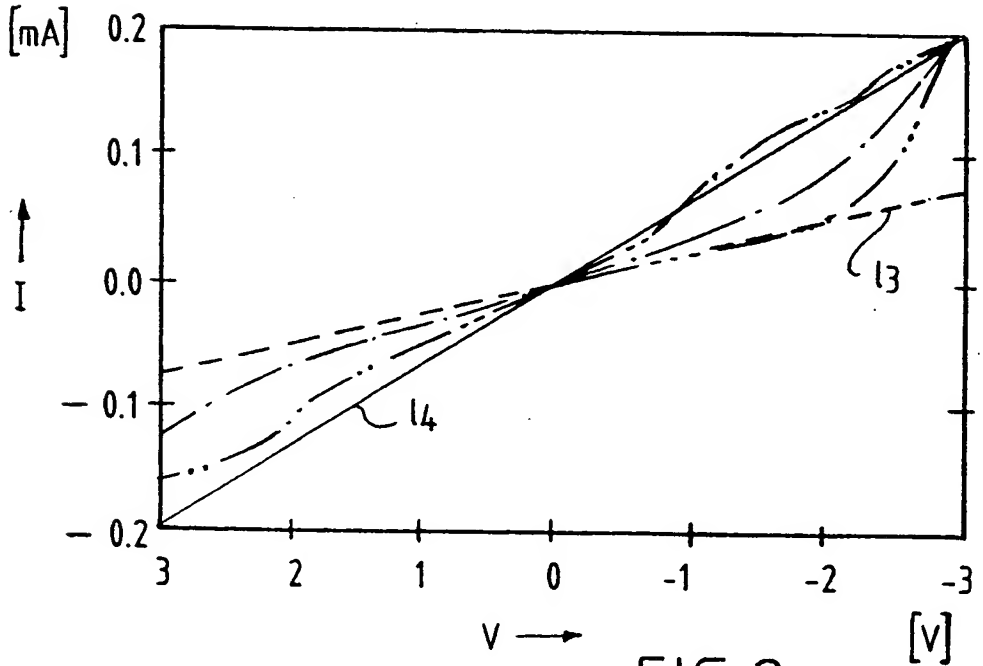
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FIG.2

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EUROPEAN SEARCH REPORT

Application Number

EP 91 20 1794

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	IBM TECHNICAL DISCLOSURE BULLETIN, vol. 26, no. 7B, December 1983, pages 3579-3580, New York, US; W.R. SMITH: "Closed-loop control of the "Z" stage of a wafer prober" * Page 3580 *	1,6,8	G 01 R 27/20
A	INTERNATIONAL TEST CONFERENCE 1989, PROCEEDINGS, Washington, DC, 29th - 31st August 1989, pages 208-215, IEEE, New York, US; N. NADEAU et al.: "An analysis of tungsten probes' effect on yield in a production wafer probe environment"		
A	RADIO FERNSEHEN ELEKTRONIK, vol. 34, no. 7, July 1985, pages 415-417, Berlin, DE; F. BAGE: "Elektrisches Kontaktverhalten von Sondennadeln"		
A	DE-A-3 843 877 (KABELMETAL)		
A	ELEKTRIE, vol. 25, no. 8, August 1971, pages 303-304; B. NOVOTNY: "Verfahren zur Ermittlung von Kontaktwiderständen"		TECHNICAL FIELDS SEARCHED (Int. Cl.5) G 01 R

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	10 January 91	HOORNAERT W.

CATEGORY OF CITED DOCUMENTS

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